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BOTANY.—*Revision of Ichthyomethia, a genus of plants used for poisoning fish.* S. F. BLAKE, Bureau of Plant Industry.

The genus Ichthyomethia, belonging to the tribe Dalbergieae of the family Fabaceae, is of economic importance among the aborigines of tropical America as one of the plants commonly used as a fish poison. Its use for this purpose in Jamaica, where it is called dogwood, was so well described by Patrick Browne[1] that it is only necessary to cite his quaint account.

> The bark of the root of this tree is used for the same purposes, and with the same effects, as the leaves and branches of Surinam poison, already described: it is pounded, and mixed with the water in some deep and convenient part of the river, or creek, etc., from whence it may spread itself more diffusively around; and in a few minutes after it is well mingled, you'll see the fish, that lay hitherto hid under the neighboring rocks, or banks, rising to the surface, where they float as if they were dead; in which situation they continue for a considerable time; but most of the large ones that are left, recover after a time; while the smaller fry are all destroyed, and float upon the surface, for some days after. The eel is the only fish I have observed, that could not be intoxicated with the common doses of this bark, though it affects it very sensibly; for the moment the particles spread where it lies, it moves off, and swims with great agility through the water. I have sometimes seen them chased to and fro, in this manner, for some minutes, without being any ways altered.
>
> The tree is generally considered as one of the best timber-trees in the island. The wood is very hard, and resinous; and lasts almost equally in or out of water. It is of light brown color, coarse, cross-grained, and heavy.

The bark of the roots of the genus has found some application in eclectic medicine, under the name Piscidia or Piscidia bark,

[1] Nat. Hist. Jam. 296. 1756.

but it is not listed in the United States Dispensatory. The active principle, according to Hart as quoted by Felter and Lloyd,[2] is a neutral body, piscidin ($C_{29}H_{24}O_8$), which has narcotic and analgesic properties. It has been used for alleviating insomnia and neuralgia, for allaying spasms, and for similar purposes. Experimentally it has been found to bring about death in animals by causing heart failure or by arresting respiratory action.

Although this genus has generally been known under the name Piscidia, given it by Linnaeus in 1759, it is necessary under the American Code of Botanical Nomenclature to adopt for it the name Ichthyomethia, published by Patrick Browne in 1756, with a reference to the original species, *Erythrina piscipula* L.

In addition to the original species, *Ichthyomethia piscipula* (L.) Hitchc. (*Erythrina piscipula* L., 1753; *Piscidia erythrina* L., 1759), and some species wrongly ascribed to the genus by early authors, four species have been described: *Piscidia Americana* Moc. Sessé, *P. mollis* Rose, *P. cubensis* Urban, and *Ichthyomethia havanensis* Britton & Wilson. A sixth species is *Derris grandifolia* Donn. Smith, the fruit of which, unknown to the describer of the species, shows it to be a member of this genus. In addition to these species, study of the specimens in the National Herbarium, supplemented by material from the New York Botanical Garden and the Gray Herbarium, has shown the existence of three new species, closely related to *I. piscipula* but distinguished by constant characters and definite geographical ranges. My thanks are due to the curators of the herbaria mentioned for the loan of the material.

Of the eight species here recognized, three (*I. grandifolia*, *I. mollis*, and *I. cubensis*) are very distinct in characters of foliage and pubescence. The other five form a closely related group centering around the original species, *I. piscipula*. In making out the characters which distinguish these species, and in correlating them with distribution in definite floristic regions, I am indebted for advice and assistance to Mr. William R. Maxon. The first of these, *I. piscipula*, definitely known as a native only

[2] King's Amer. Dispensatory ed. XI. (3d revision) 2: 1510. 1900.

of Jamaica, is distinguished by having the leaves evenly but not densely short-pilose beneath with spreading-ascending, usually rufescent hairs, while in the other four species they are merely puberulous to strigose. In two of these, *I. havanensis* and *I. communis*, the leaves are densely puberulous beneath with incurved or ascending hairs, which are more numerous along the veins and veinlets and coincide with them in direction. In the remaining two species, *I. americana* and *I. acuminata*, the leaves are distinctly strigose or strigillose beneath, and the hairs, except along the costa and the primary lateral veins, do not follow the direction of the nervation, but all point toward the margin of the leaf; in consequence of which the hairs which arise from the secondary and tertiary veinlets diverge from their veinlets at approximately a right angle, and those which arise from the surface below and near the veinlets lie across the latter transversely. Associated with these characters of pubescence is a difference in the ceraceous covering of the under leaf surface. In *I. communis* the waxy covering is comparatively thick and is divided by the ultimate veinlets into definitely raised areoles. In most of the other species it is thinner and flatter and, owing to the weaker development of the veinlets, does not have the same areolate appearance.

Piscidia carthagenensis, Jacq.,[3] briefly described by Jacquin from fruiting material collected at Cartagena, was said to differ from *P. erythrina* L. in its obovate, much larger leaflets. No material from Colombia has been seen by the writer, and Jacquin's account is so incomplete that is it necessary for the present to leave the identity of the species in doubt. It is presumably most closely related to *I. acuminata*, and may prove to be identical. DeCandolle's account of *P. carthagenensis* in the Prodromus[4] evidently applies in part to *Ichthyomethia piscipula* and perhaps to other species not then distinguished.

Loefling's *Piscipula erythrina*,[5] incompletely described from trees found by Loefling in northeastern Venezuela, is perhaps

[3] Enum Pl. Carib. 27. 1760; Stirp. Amer. 210. 1763.
[4] Prodr. 2: 267. 1825.
[5] It. Hisp. 275. 1758.

identical with Jacquin's *P. carthagenensis*. As Loefling gives no account of the pubescence of the leaves, it is impossible in the absence of specimens to be certain of the identity of his plant.

The only South American material of the genus in the herbaria which the writer has examined consists of fruits in the National Herbarium collected at Río Macara, Ecuador, altitude 455 to 610 meters, April, 1910, by C. H. T. Townsend (no. 849), and leaves in the Gray Herbarium collected on Chatham Island, Galápagos Islands, 1899, by Snodgrass and Heller (no. 503). Both these collections are too imperfect for specific determination.

Ichthyomethia P. Br. Nat. Hist. Jam. 296. 1756.

Piscipula Loefl. It. Hisp. 275. 1758.
Piscidia L. Syst. ed. 10. 1155. 1759.

Trees or shrubs, not climbing; leaves odd-pinnate, the leaflets opposite; flowers in lateral panicles, appearing before the leaves; calyx campanulate, obscurely 2-lipped, the upper lip emarginate, the lower 3-lobed, the teeth deltoid; flowers rosy or white and red, rarely yellowish white; vexillum suborbicular or oval-obovate, emarginate, short-clawed; wings falcate-oblong, long-clawed, adherent to keel near middle, the limb auriculate above at base; keel obtuse, its petals long-clawed, their limbs united near middle for about one-third their length, auriculate-sagittate on upper side at base; stamens 10, the vexillar one free at base for one-quarter to one-half its length, or rarely free throughout; ovary sessile, many-ovulate; style filiform, incurved, glabrous, with a small terminal stigma; legume indehiscent, firm, with linear body, broadly or narrowly 2-winged on each suture, stipitate, 1 to 6-seeded, in age tending to break transversely between the seeds.

Type species, *Erythrina piscipula* L.

KEY TO SPECIES

Wings as broad as or much broader than the body of the fruit; leaflets 3 to 12 cm. long.

Leaves very densely and softly cinereous-tomentulose or pilose beneath; vexillum glabrous (so far as known); vexillar stamen entirely free (so far as known).

Leaves densely tomentulose beneath.....1. *I. grandifolia.*

Leaves densely short-pilose beneath.....2. *I. mollis.*

Leaves puberulous, strigose, or short-pilose beneath; vexillum densely pubescent; vexillar stamen free for one-fourth to one-half its length.

Leaves puberulous to strigose beneath.

Leaves densely incurved-puberulous or ascending-puberulous beneath, the hairs more numerous along the veinlets and parallel with them; stipe of fruit equaling or slightly exceeding the calyx.

Low shrub; petiole and rachis spreading-puberulous; leaflet prominulous-reticulate beneath; fruit 1.2 to 3.5 cm. long ..... 3. *I. havanensis.*

Tree; petiole and rachis strigillose or appressed-puberul ous; leaflets not prominulous-reticulate beneath; fruit 2.5 to 7.5 cm. long..... 4. *I. communis.*

Leaves strigose or strigillose beneath, the hairs not more numerous along the veinlets, crossing them transversely; stipe of fruit much exceeding the calyx.

Lobes of lower lip of calyx obtuse or rounded..... ..... 5. *I. americana.*

Lobes of lower lip of calyx short-acuminate..... ..... 6. *I. acuminata.*

Leaves short-pilose beneath with spreading-ascending hairs..... 7. *I. piscipula.*

Wings much narrower than the body of the fruit; leaflets 1 to 2 cm. long..... 8. *I. cubensis.*

1. **Ichthyomethia grandifolia** (Donn. Smith) Blake.

Derris grandifolia Donn. Smith, Bot. Gaz. **56**: 55. 1913.

Tree, with stout branches; shoots of the year cinereous-tomentulose, the older branches glabrate; leaves 7 to 11-foliolate, 18 to 33 cm. long; petiole, rachis, and petiolules densely cinereous- or sordid-tomentulose with crisped spreading hairs; leaflets 5.5 to 10 cm. long, 3 to 6.5 cm. wide, oval or the lowest ovate, broadly rounded, mucronulate, rounded at base, thick, above dull green, densely crisped-pilosulous, beneath densely cinereous-tomentulose with crisped spreading hairs, these in youth concealing the secondary veins; panicles cylindric, dense, 10 to 15 cm. long, sordid-tomentulose; pedicels 1.5 to 4.5 mm. long; calyx 7 to 8 mm. long, densely sordid-pilosulous, the lobes of lower lip deltoid-triangular, short-acuminate; vexillum oval-obovate, glabrous, 10 mm. long; alae 12 mm. long (the claws 5.5 mm. long), the limb ciliate on lower edge toward base; keel 13.5 mm. long, glabrous; vexillar stamen entirely free; fruit 4 to 9 cm. long, 2.5 to 5 cm. wide, 3 to 5-seeded, densely sordid-pilosulous, the wings usually not divided, as broad as or broader than the body, the stipe exceeding the calyx by 1 to 3 mm.

TYPE LOCALITY: Cerro Gordo, Guatemala.

SPECIMENS EXAMINED:

PUEBLA: Zapotitlán, 1908, *Purpus* "= 2648."

OAXACA: Near Dominguillo, altitude 1370 to 1675 meters, 1894, *Nelson* 1826.

GUATEMALA: Volcán Imay, Dept. Jalapa, altitude 1525 meters, 1908, *Kellerman* 8048 (N. Y. Bot. Gard.). Cerro Gordo, Dept. Santa Rosa, altitude 1100 meters, August, 1892, *Heyde & Lux* 3709 (type collection).

This species departs from other members of the genus in its glabrous banner and its free vexillar stamen. The flowers of the next species,

I. mollis, have not yet been collected, but from the agreement in other features it is probable that they will show the same peculiarities. The fruit of both species is precisely that of the type species of Ichthyomethia, and the character of the stamens is known to vary in the same way in related genera of this group.

2. Ichthyomethia mollis (Rose) Blake.

Piscidia mollis Rose, Contr. U. S. Nat. Herb. **1**: 98. 1891.

Tree, 3 to 8 meters high; branches rather slender, softly cinereous-tomentulose, in age glabrate; leaves 7 to 13-foliolate, 8 to 20 cm. long; petiole, rachis, and petiolules densely cinereous-tomentulose; leaflets 3 to 7.8 cm. long, 2 to 4 cm. wide, oval to ovate, acute to rounded, at base rounded, whitish green on both sides, above densely pilosulous with crisped hairs, beneath densely and softly short-pilose with ascending hairs, in age prominulous-reticulate; fruit 2.5 to 5 cm. long, 3.5 to 4.5 cm. wide, 1 to 3-seeded, densely cinereous-puberulous, the wings much wider than the body of the fruit, sometimes split in age.

TYPE LOCALITY: Ridges about Alamos, Sonora.

SPECIMENS EXAMINED:

SONORA: Alamos, 1890, *Palmer* 355 (type collection). Dry hills, Alamos, 1910, *Rose, Standley, & Russell* 12906, 13515. Near Torres, 1903, *Coville* 1659.

This species is distinguished from *I. grandifolia* by having its leaflets pilose rather than tomentose beneath. The flowers have not yet been collected. The plant bears the vernacular name "palo blanco." One of the specimens collected by Rose, Standley, and Russell, under their number 12906, is remarkable in having dull green, rather sparsely pilosulous leaves. It is doubtless a sucker growth or young shoot of the plant, and is not properly to be taken as indicating variation in the adult leaves, all those examined being very constant in both color and pubescence.

3. Ichthyomethia havanensis Britton & Wilson, Bull. Torrey Club **44**: 34. 1917.

Shrub, 2 meters high; branchlets sparsely puberulous, in age fuscous, glabrate; leaves 9-foliolate, 10 cm. long; petiole and rachis rather densely sordid-puberulous with spreading hairs; leaflets (immature) 3.5 cm. long, 1.5 cm. wide, elliptic to oblong-oval, obtuse to rounded, mucronulate, at base cuneate-rounded, above dull green, spreading-puberulous, glabrescent, beneath paler, prominulous-reticulate, densely puberulous with ascending hairs somewhat more numerous along the veins; calyx 5 mm. long, densely rufescent-strigillose, the teeth deltoid, obtuse; fruit, 1.2 to 3.5 cm. long, 2 to 2.8 cm. wide, 1 to 3-seeded, appressed-puberulous, the wings much wider than the body, usually undulate-divided.

TYPE LOCALITY: Near Cojimar, Havana, Cuba.
SPECIMENS EXAMINED:
CUBA: Thickets not far from Cojimar, May 14, 1915, *León & Roca* 6194 (type; N. Y. Bot. Gard.).

This species, of which only the type, in fruit and young leaf, has been examined, is distinguished from the next by its smaller fruit and smaller leaflets, these prominulous-reticulate beneath, as well as by the pubescence of the rachis and petiolules.

4. **Ichthyomethia communis** Blake, sp. nov.

Tree, 20 meters high or less; branchlets strigillose, soon glabrate; leaves 7 or 9-foliolate, 12 to 22 cm. long; petiole and rachis sordid-strigillose or appressed-puberulous, sometimes glabrate in age; leaflets 4 to 12 cm. long, 2 to 5 cm. wide, oblong or elliptic to obovate-oval, acute or short-pointed, rounded to cuneate at base, above green, appressed-puberulous, at length glabrate, beneath pale, not prominulous-reticulate, densely incurved-puberulous, the hairs more numerous along the veins; panicles 3 to 9 cm. long, many-flowered, often branched from base, finely griseous-puberulous; pedicels 2 to 6 mm. long; calyx 4.5 mm. long, densely cinereous-puberulous; the teeth of lower lip broadly deltoid, obtuse or rounded; vexillum 12.5 mm. long, suborbicular, densely cinereous-pubescent on back; alae about 15 mm. long (the claws 7 mm. long), the lamina sparsely pubescent; keel 12 mm. long (the claws 6.5 mm. long), the petals pubescent below, the claws ciliate beneath above the middle; vexillar stamen free for one-fourth to one-half its length; fruit 2.5 to 7.5 cm. long, 2.8 to 4 cm. wide, 1 to 6-seeded, cinereous-puberulous, especially on the body, the wings much wider than the body, usually undulate-divided, the stipe equaling the calyx or exceeding it by only 6 (rarely 9) mm.

Type in the U. S. National Herbarium, no. 41958, collected in forests on coral soil, Ramrod Key (flowers), and on Jewfish Key, Florida (leaves and fruit), May and July, by A. H. Curtiss (no. 685).
OTHER SPECIMENS EXAMINED:
FLORIDA: Miami, 1877, *Garber*. Punta Rassa, Lee County, 1900, *Hitchcock* 76; 1916, *Miss J. P. Standley* 257. Marco, Lee County, 1916, *P. C. Standley* 12732. White Horse Key, and Key West, 1891, *Simpson* 234. Palm Cape, *Chapman* 34.
TAMAULIPAS: Tampico, 1910, *Palmer* 510.
SAN LUIS POTOSÍ: Limestone hills, Rascón, 1892, *Pringle* 4110.
VERACRUZ: Pueblo Viejo, near Tampico, 1910, *Palmer* 541 (N. Y. Bot. Gard.).
YUCATÁN: Mérida, 1865, *Schott* 260. Sisal, 1916, *Gaumer & Sons* 23219. Without definite locality, 1895, *Gaumer* 524.
HONDURAS: Ruatan Island, 1886, *Gaumer* 154.
CUBA: Manzanillo, 1912, *Shafer* 12349. Ensenada de Mora, Oriente, 1912, *Britton, Cowell, & Shafer* 12926 (N. Y. Bot. Gard.).

This species, the commonest and most widely distributed of the genus, has not previosuly been distinguished from *I. piscipula*. It is readily separated, however, by the leaves, which in *I. communis* are densely incurved-puberulous beneath, with the hairs along even the ultimate veinlets parallel to the latter. In *I. piscipula* the leaves are short-pilose with spreading-ascending hairs beneath, and the hairs along the veinlets do not coincide with them in direction but lie across them transversely.

I. communis is called "haabí" by the Mayas of Yucatán, and "chijol" by the Huastecan Indians of Tamaulipas and Veracruz.

5. **Ichthyomethia americana** (Moc. & Sessé) Blake.

Piscidia americana Moc. & Sessé, Pl. Nov. Hisp. 116. 1887.

Tree; branchlets appressed-puberulous, soon glabrate; leaves 9 to 13-foliolate, 12 to 20 cm. long; petiole and rachis appressed-pubescent, glabrescent, leaflets 4 to 8 cm. long, 1.7 to 4 cm. wide, oval-oblong or elliptic-oblong or the terminal one obovate-oval, rounded or obtuse, sometimes acute, rounded at base, pergamentaceous, above light green, glabrous, beneath pale, evenly but not densely short-strigose, the hairs on the costa and primary veins appressed to them, those on the secondary and tertiary veinlets and on the surface directed toward margin of leaf, thus crossing the veinlets nearly at a right angle, and not more numerous along than between them; panicles 8 to 24 cm. long, strigillose; pedicels 2 to 7 mm. long; calyx 6 to 7 mm. long, cinereous-puberulous with appressed hairs, the lobes of lower lip deltoid-ovate or broadly deltoid, slightly overlapping near base, obtuse or rounded, rarely acutish at tip; vexillum 15 mm. long, densely cinereous-puberulous dorsally, in youth subsericeous; alae 15.5 mm. long (the claws 7 mm. long), the laminae sparsely puberulous toward base; keel 15 mm. long (the claws 7 mm. long), the petals puberulous below; vexillar stamen free for one-third its length; fruit 1.5 to 7.5 cm. long, 1.8 to 4.3 cm. wide, 1 to 6-seeded, appressed-puberulous, the glabrescent wings much wider than the body, often undulate-divided, the stipe exceeding the calyx by 6 to 12 mm.

TYPE LOCALITY: Apatzingan, Michoacán, Mexico.

SPECIMENS EXAMINED:

MICHOACÁN: Hacienda Guadalupe, near Río Balsas, 1903, *Nelson* 6969. Nusco (Michoacán or Guerrero), 1899, *Langlassé* 936.

GUERRERO: La Junta, 1903, *Nelson* 6991.

GUATEMALA: Naranjo, altitude 90 meters, 1892, *J. D. Smith* 2815.

This species is called "tatzungo" or "zatzumbo" by the Tarascan Indians of Michoacán, according to Mociño and Sessé. In Guerrero it is known by the native name "cocuile" and the Mexican names "colorín de peces" and "matapez." Although there is little in the description

of Mociño and Sessé to differentiate this species, its identity is clear from the locality.

6. **Ichthyomethia acuminata** Blake, sp. nov.

Tree; branchlets strigillose, soon glabrate; leaves 7 to 11-foliolate, 17 to 30 cm. long; petiole and rachis strigillose, glabrescent; leaflets 4 to 13 cm. long, 2.2 to 7 cm. wide, oval to ovate-oval, or the terminal one obovate-oval or rarely suborbicular, obtuse or rounded, rarely short-pointed, rounded at base, pergamentaceous, above light or dark green, glabrous or essentially so, beneath paler, evenly but not densely strigose or strigillose, the hairs lying across the prominulous secondary and tertiary veins and not more numerous along them than between them; panicles 10 to 30 cm. long, strigillose; pedicels 4 to 8 mm. long; calyx 5 to 6 mm. long, densely cinereous-strigillose, the lobes of lower lip deltoid, acute or acuminate; flowers "pink;" vexillum 13 to 15 mm. long, densely cinereous-strigose dorsally, in youth subsericeous; alae 15 to 18 mm. long (the claws 6.5 to 8 mm. long), the laminae sparsely pubescent; keel 14 mm. long (the claws 6 mm. long), the petals pubescent below, the claws ciliate below above the middle; vexillar stamen free for one-quarter to one-half its length; fruit 2 to 8.5 cm. long, 2.5 to 4 cm. wide, 1 to 5-seeded, strigillose, the wings much wider than the body, often undulate-divided, the stipe exceeding the calyx by 8 to 13 mm.

Type in the U. S. National Herbarium, no. 639557, collected in Antigua, Lesser Antilles, February 4–16, 1913, by J. N. Rose, W. R. Fitch, and P. G. Russell (no. 3419).

OTHER SPECIMENS EXAMINED:

PORTO RICO: Playa de Fajardo, 1913, *Britton & Shafer* 1575. Punta Guaniquilla, 1915, *Britton, Cowell, & Brown* 4576.

CULEBRA: Culebra, 1906, *Britton & Wheeler* 62.

VIEQUES ISLAND: Punta Arenas to Boca Quebrada, 1914, *Shafer* 2912.

TORTOLA: Road Town to Sea Cow Bay, 1913, *Britton & Shafer* 684.

ST. CROIX: Christiansted, 1913, *Rose, Fitch, & Russell* 3579. Without definite locality, 1896, *Ricksecker* 320.

ST. JAN: Bethania, 1913, *Britton & Shafer* 336.

MONTSERRAT: Without definite locality, 1907, *Shafer* 462.

GUADELOUPE: Without definite locality, altitude 250 meters or less, 1892, *Duss* 2662.

BARBADOS: Dover or Constitution Hill, Farley Hill, 1895, *Waby* 83.

TOBAGO: Scarborough, 1914, *Broadway* 4808.

This species and the preceding (*I. americana*) are distinguished from the other species of the *I. piscipula* type by the character of their pubescence and by the long stipe of the fruit. They are distinguished from one another chiefly by the shape of the lower calyx lobes, which are acute or short-acuminate in the present plant and taper from the

base, while in *I. americana* they are obtuse or rounded, or rarely slightly acutish at the extreme tip.

I. acuminata is known as "bois énivrant" and "bois à énivrer" in the French Islands of the Lesser Antilles, and as "ventura" in Porto Rico.

7. **Ichthyomethia piscipula** (L.) Hitchc.; Sarg. Gard. & For. 4: 472. Oct. 1891.[6]

Erythrina piscipula L. Sp. Pl. 2: 707. 1753.
Piscidia erythrina L. Syst. ed. X. 1155. 1759.
"*Piscidia inebrians* Medic. Vorles. Churpf. Phys. Ges. 2: 394. 1787."
"*Piscidia toxicaria* Salisb. Prodr. 336. 1796."
Piscidia piscipula Sarg. Gard. & For. 4: 436. 1891.

Tree, 12 meters high or less; branchlets rufescent-strigillose, glabrate; leaves 7-foliolate, 22 to 26 cm. long; petiole and rachis rufescent-strigose or strigillose; leaflets 5.5 to 11.5 cm. long, 4.5 to 7 cm. wide, oval or obovate-oval, rounded or short-pointed, at base rounded to slightly cordate, pergamentaceous, above deep green, strigillose-puberulous, glabrate, beneath slightly paler, prominulous-reticulate, rather densely short-pilose with spreading-ascending, usually somewhat rufescent hairs, these somewhat more numerous and more or less appressed along the costa and primary veins, those along the veinlets crossing them transversely and not more numerous than on the surface between them; panicles numerous, 5 to 16 cm. long, strigillose, much branched; pedicels 4 to 7 mm. long; calyx 5.5 to 6 mm. long, densely cinereous-strigillose, the lobes of lower lip deltoid, the lateral ones broadly rounded or obtuse, the middle one acute or acutish; corolla rosy or "white and red;" vexillum 13 mm. long, densely strigillose dorsally, in youth subsericeous; alae 13.5 mm. long (the claws 6 mm. long), the lamina sparsely pubescent along midline; keel 12 mm. long (the claws 5.5 mm. long), the petals pubescent and short-ciliate below, their claws short-ciliate below above the middle; vexillar stamen free for one-fourth its length; fruit 2.5 to 7 cm. long, 2.5 to 4 cm. wide, 1 to 6-seeded, cinereous-pubescent especially on the body, the wings much wider than body, often undulate-divided, the stipe exceeding calyx by 2 to 6 mm.

TYPE LOCALITY: "In America calidiore." Linnaeus's references all relate primarily to Jamaica.

SPECIMENS EXAMINED:

JAMAICA: Morant Bay, 1850, *March* (N. Y. Bot. Gard.). Berwich Hill, altitude 760 meters, 1899, *Harris* 7708. Hope Grounds, altitude 640 meters, 1903, *Harris* 8518 (N. Y. Bot. Gard.). Great Goat Island, 1906, *Harris* 9221. Vicinity of Kingston, 1910, *Brown* 364 (N. Y. Bot. Gard.).

The use of this species by the natives of Jamaica as a fish poison was known to many of the older writers. The species was apparently

[6] This combination was also published in November, 1891, by Kuntze (Rev. Gen. 1: 191).

first listed by Hermann,[7] in 1689, as "Coral arbor polyphylla non spinosa." Sloan,[8] in 1696, gave a long list of trees, mentioned by still older writers and travellers as fish poisons, which he doubtfully referred to this species. Ray,[9] in 1704, gave a good description of the plant and mentioned its use. A figure of the leafless flowering branch and of a portion of the fruit, with an account of this species and of other fish poisons, was also given in Sloane's Natural History of Jamaica.[10]

Ichthyomethia piscipula is readily distinguished by the pubescence of its leaves, and is probably confined as a native to Jamaica, where it is known as "dogwood." In the National Herbarium is a sheet from Key West, collected in 1896 by A. H. Curtiss (no. 5656), and another collected in Florida in 1877 by Garber. It is probable that both these specimens were taken from cultivated trees.

8. **Ichthyomethia cubensis** (Urban) Blake.

Piscidia cubensis Urban, Symb. Antill. 7: 229. 1912.

Shrub, 1 to 1.3 meters high; young branches greenish, densely rufescent-strigillose, the older branches gray, lenticellate, glabrate; leaves 5 to 9-foliolate, 2.5 to 4.5 cm. long; petiole (3 to 7 mm. long), rachis, and petiolules (1 mm. long) densely rufescent-strigillose; leaflets 1 to 2 cm. long, 6 to 11 mm. wide, oval to oblong, emarginate, apiculate, at base rounded to subcordate, coriaceous, prominulous-reticulate beneath, above light green, lucid, sparsely strigillose toward margin or glabrous, beneath obscurely strigillose chiefly along the veins; panicles rufescent-strigillose, 2 to 2.5 cm. long; pedicels 2 to 4 cm. long; calyx rufescent-strigillose, 4 mm. long, the lobes of lower lip deltoid, broadly rounded; corolla "pink or white" or "yellowish white;" vexillum 12.5 mm. long, subsericeous-strigose when young; lateral petals 13 mm. long (the claws 7 mm.), the limbs sparsely pubescent at base, sparsely ciliate at apex; keel 12.5 mm. long, (the claws 6.5 mm.), the limbs of the petals sparsely pubescent below toward base; vexillar stamen free for one-third its length; fruit linear, straightish, rufescent-strigillose, sometimes constricted between the seeds, 1 to 6-seeded, 2 to 4.8 cm. long, 5 to 7 mm. wide; wings 4, only 1 mm. wide; stipe equaling calyx; seeds olive-fuscous, 4.8 mm. long.

TYPE LOCALITY: Riverside to Minas, Camaguey, Cuba.

SPECIMENS EXAMINED:

CUBA: Dry savanna, Riverside to Minas, Camaguey, April 1, 1909, *Shafer* 1171 (type collection; N. Y. Bot. Gard.). Rocky soil, Palm Barren, Santa Clara, March, 1911, *Britton & Cowell* 10179 (N. Y. Bot. Gard.). Rocky sides of arroyo, Palm Barren, April, 1912, *Britton & Cowell* 13293 (N. Y. Bot. Gard.).

[7] Par. Bat. Prodr. 328. 1689.

[8] Cat. Pl. Jam. 143. 1696.

[9] Hist. Pl. 3 (lib. xxxi.): 108. 1704.

[10] Voy. Jam. 2: 39. *pl. 176. f. 4–5.* 1725.

This very distinct species was described by Urban from Shafer's nos. 1171 and 1549, of which the former is here selected as type. Urban gives the maximum size of the leaflets as 2.5 cm. long, and 1.7 cm. wide, and the fruit as having wings up to 2 mm. broad.

Although the fruit of this species is very different in appearance from that of the other members of the genus, owing to the great reduction of the wings, the difference is only a comparative one. In its floral structure *I. cubensis* agrees precisely with other members of the genus, and the morphology of the fruit is the same.

ELECTRICITY.—*Methods of measuring conductivity of insulating materials at high temperatures.* F. B. SILSBEE and R. K. HONAMAN, Bureau of Standards.

The purpose of this paper is to describe some measurements carried out at the Bureau of Standards during the past two years, on the resistance of various insulating materials at high temperatures. This work was undertaken with a view to studying the relative merits of various insulators for use in spark plugs, and in particular to assist the Ceramic Laboratory of the Bureau in developing improved porcelain bodies for this purpose. The method finally adopted, as a result of this work, for the comparative testing of materials is described elsewhere.[1] The present paper will be confined to a description of the various phenomena observed in the experiments which led to the method finally adopted.

The electrical and thermal conditions under which a spark plug is required to operate differ considerably with the type of gasoline engine used. Measurements with imbedded thermocouples have shown that the temperature of the body of the insulator within the metal shell seldom exceeds 250° C. in water-cooled engines. The tip of the inner end, however, may reach temperatures as high as 900 to 1000° C. It therefore appeared desirable to study the resistivity of the specimens in the range of temperature between 200 and 900° C.

The electrical stresses applied to a spark plug insulator by the average magneto or battery coil ignition system used for firing gasoline engines, are quite peculiar and difficult to duplicate in

[1] Report of the National Advisory Committee for Aeronautics, 1918.

any method of measurement. The cycle of operation, following the opening of the primary breaker contacts, consists of a rapid rise of the potential applied to the spark plug from zero to a value sufficient to break down the spark gap in the engine cylinder. The breakdown voltage is of the order of 6000 volts and is reached in a few hundred thousandths of a second. After this, a comparatively low voltage (800 volts) maintains the electric arc between the spark points and lasts for a few thousandths of a second. Since the interval between sparks is of the order of 0.05 to 0.1 second, it will be seen that the average voltage applied over a complete cycle is quite low and has been found to be approximately 150 volts. These peculiar electrical conditions should be kept in mind when considering the various methods of measurement described below.

The materials studied in this investigation included porcelains, glass, steatite, mica, and fused silica, as these constitute the only class of substances sufficiently heat resisting for use in spark plugs. While the detailed studies of polarization, etc. described in this report were made on only a few of the porcelain samples, the same effects seemed to be present to greater or less degree in all cases and the process of conduction is probably similar in all of them. The work of earlier investigators[2] has shown the complex nature of the phenomena, but as yet no complete and satisfactory theory has been worked out to account for them.

APPARATUS AND SPECIMENS

Most of the work reported in this paper was done on cup-shaped specimens with flat bottoms 3 mm. thick. The principal advantages of this type of specimen are:

(1) The conduction takes place through the bottom of the cup, which is of definite and easily measured dimensions.

(2) The large area and small thickness of the bottom ensure a relatively large current even with material of high conductivity.

[2] GRAY, T. Phil. Mag. V, 10: 226. 1880. HAWORTH, H. F. Proc. Roy. Soc. London 81 A: 221. 1908. SOMERVILLE, A. A. Phys. Rev. 31: 261. 1910. CAMPBELL. Nat. Phys. Lab. 11: 207. 1914. KINNISON, C. S. Proc. Amer. Ceramic Soc. 17: 422. 1915. POOLE, H. H. Phil. Mag. 34: 195. 1917. BRACE, P. H. Trans. Amer. Electrochem. Soc. May 5, 1918.

(3) The path over the rim of the cup for any surface leakage is relatively long.

(4) A satisfactory contact can be made between the specimen and the electrodes by immersing the bottom of the cup in a conducting fluid (in these experiments melted solder) and by inserting some of this fluid inside the cup to form the upper electrode.

These specimens were used in the furnace shown in figure 1.

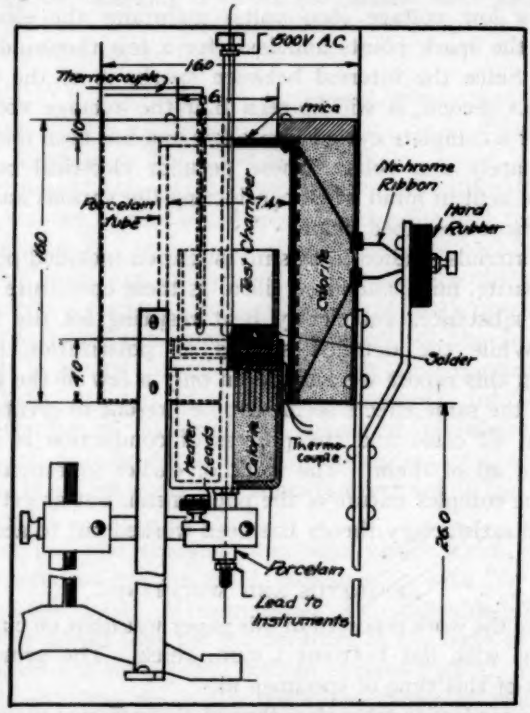

Fig. 1. Electric furnace as used in conductivity measurements.

The heating coil inserted in the plug below the specimen was found necessary to compensate for the flow of heat through the bottom of the furnace. By proper adjustment of the relative amounts of current through the main winding and through this additional coil, the temperatures inside and outside the cup could be equalized. These temperatures were measured by two copper con-

stantan thermocouples, one of which was inserted in a closed porcelain tube which dipped below the surface of the solder in the interior of the cup, while the other was imbedded in the steel cup containing the solder below the specimen. Readings of the resistance were taken only when these two thermocouples showed substantially equal temperatures.

In cases where cup specimens were not available, measurements were made on assembled spark plugs and also on spark plug insulators, and on short pieces of tubing. In these cases the conduction took place between a central electrode and either the shell of the spark plug or a band of platinum deposited around the center of the outside of the insulator or tube. The measurements with this type of specimen were definite in indicating the resistance of the specimen, but owing to the uncertainty as to the area of contact and the location of the lines of current flow, it is difficult from such data to compute with accuracy the true resistivity of the material.

For reducing the results of either type of specimen from the observed resistance to a basis of the resistivity of the material, the factors connecting these two quantities were computed from the dimensions of the specimens. For the cup specimen, the resistivity is obtained by multiplying the observed resistance by K, where

$$K = \frac{\pi d^2}{4t} \qquad (1)$$

and d is the diameter of the bottom of the cup and t the thickness of the cup in centimeters. For the tubular specimen

$$K = \frac{2\pi l}{2.30 \log_{10} \frac{R_2}{R_1}} \text{ (approx.)} \qquad (2)$$

where l equals the length of the external conducting band measured parallel to the length of the specimen, and R_2 and R_1 are respectively the external and internal radii of the insulator.

In most of the work the resistances were measured by reading a voltmeter connected across the specimen and an ammeter in series with it, and taking the quotient of these values as the re-

sistance. As will be seen from the following, a wide variety of sources was used to provide the applied voltage and the indicating instruments were correspondingly varied in character.

VARIATION OF RESISTANCE WITH TEMPERATURE.

The first experiments were carried out with an applied direct

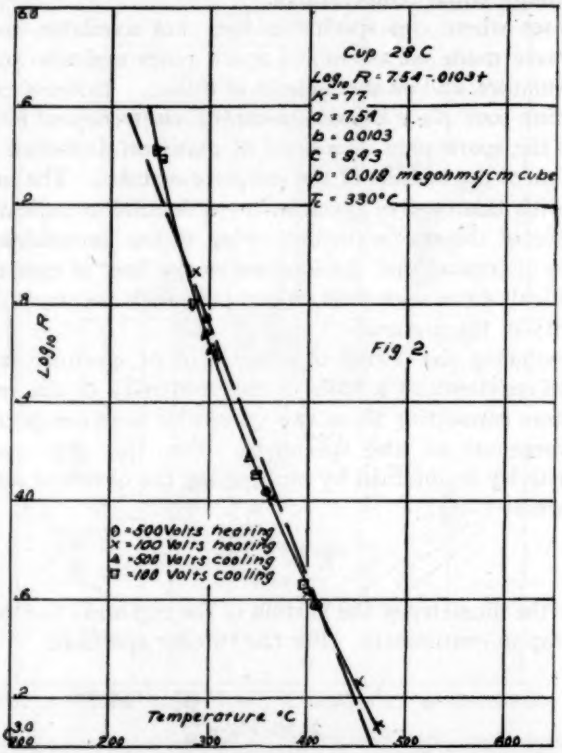

Fig. 2. Typical results on porcelain cup showing variation of resistance with temperature.

current voltage of about 2000 volts which was obtained by rectifying with a kenotron a 3000 cycle voltage supplied from a step-up transformer. This rather complicated system was chosen in an attempt to duplicate to some extent the voltages existing

in ignition systems, and although this source of voltage was later abandoned, the data obtained with it brought out the salient facts in regard to this type of conduction. The most striking of these facts, as verified by other measurements made later, is the very rapid decrease in resistance of the specimen with increase in temperature. This variation amounts to approximately 2 per cent per degree Centigrade at all temperatures. If the results are expressed by plotting resistance against temperature, or conductance against temperature the resulting curves are so steep as to render it impracticable to express the data over an extended temperature range by a single curve. It is found, however, that by plotting the common logarithm of the resistance against temperature, as in figure 2, a convenient line of slight curvature is obtained, and if this curvature is neglected, the results can be represented approximately by the equation

$$\log_{10} R = a - b\,t \qquad (3)$$

This method of expressing the results is very convenient in reducing the data to a basis of resistivity, since combining the relation

$$\rho = K \times R \qquad (4)$$

with equation (3) one obtains

$$\log_{10} \rho = a + \log_{10} K - b\,t = c - b\,t \qquad (5)$$

In this equation b and c are constants of the material and are independent of the shape and size of the specimen used. Unfortunately, however, the values obtained for one of these constants depends very markedly upon the other, so that a slight error in one will cause a compensating change in the other. They are, therefore, not well suited for comparing the relative merits of the different materials and for this latter purpose it has been found convenient to compute an "effective temperature" (T_e), which is defined as the temperature at which the material has the arbitrarily selected resistivity of one megohm per centimeter cube, and which may be computed from the equation

$$T_e = \frac{c - 6}{b} \qquad (6)$$

This value of T_s ranges from 350° C. in the poorer grades of porcelain up to 800° C. for fused silica, and is a convenient index of the value of the material as an insulator at high temperatures. There is a complete absence of any critical temperature at which the material undergoes an abrupt change in its resistance. This shows the error of the commonly accepted idea that porcelain breaks down and becomes conducting at a definite temperature. This belief probably originated from experiments in which the temperature of a porcelain sample was gradually raised while being continuously subjected to an applied voltage. The effect of the current flowing through the sample in such cases would be entirely negligible up to a certain temperature at which the power, $\frac{E^2}{R}$, supplied by the measuring current, became comparable with the rate at which heat could be dissipated to the surroundings. Owing to the very rapid rate of change of resistance with temperature, a very slight further increase in temperature would materially decrease the resistance and consequently increase the $\frac{E^2}{R}$ loss. Unless the specimen was in a position to give off heat freely to its surroundings, the temperature would rise rapidly causing a further decrease in resistance, thus leading to an unstable state which would rapidly cause the fusion of the material and the passage of an arc. The rapidity of change of resistance with temperature makes this point of instability quite definite, provided all the conditions of the experiment are maintained constant, but this apparent critical temperature will depend very greatly upon the contact between the specimen and the furnace, upon the applied voltage and other conditions, so that this is in no sense a specific property of the material.

The magnitude of this heating effect is exemplified by the behavior of a porcelain sample tested when hot, for example at 500° C. At this temperature, the resistance of a centimeter cube of ordinary porcelain is about 100,000 ohms, and if a voltage of only 500 volts per millimeter (*i. e.*, only about $^1/_{20}$ of that required to puncture it while cold) be applied, the current flowing will be 50 milliamperes and the power dissipated in the sample will be

250 watts. This will suffice to raise the temperature of the sample at a rate of about 100° C. per second and will cause its rapid destruction.

This heating of the specimen by the measuring current was observed on numerous occasions when making tests at 2000 and 1000 volts, and in each case the samples on removal from the furnace were found to contain one or more spots where the porcelain had been fused into a glass by the intense local heating. In the later work at lower voltage, this effect was not present, and readings were taken only when the current was substantially constant.

POLARIZATION

The early measurements with high voltage direct current showed a number of puzzling discrepancies, such as a variation of the apparent resistance with the voltage used in making the measurement and with the time of application of this voltage. Such discrepancies indicated the presence of an additional phenomenon to be reckoned with, which in the absence of definite knowledge as to its origin was called "polarization" and will be so referred to throughout this report.

The fundamental manifestation of this so-called polarization is that if a constant D. C. voltage be applied to a specimen, the resulting current will decrease at first rapidly, and then more gradually. The reduction in current is often equivalent to an increase in resistance by a factor of 10 or 20. If the specimen is allowed to remain at a high temperature but without applied voltage for some time, the effect gradually disappears, but a considerable time is required to accomplish this. The disappearance is more rapid at high temperatures than at low. Figure 3 gives a record of the variation of the apparent resistance of a glass beaker, as measured with 1000 volts D. C. after various applications and removals of the measuring potential. The course of the experiment is indicated by the arrows and the duration of each period of application or of rest is indicated on the curve. The lowest and highest curves give the resistance as observed with very short application of the testing voltage just prior to the

polarizing test, and on the following day, respectively. The apparent permanent increase of resistance observed with this specimen serves to explain some mysterious results obtained at an earlier date, in which one specimen had shown an increase of resistance to more than twenty times its initial value after

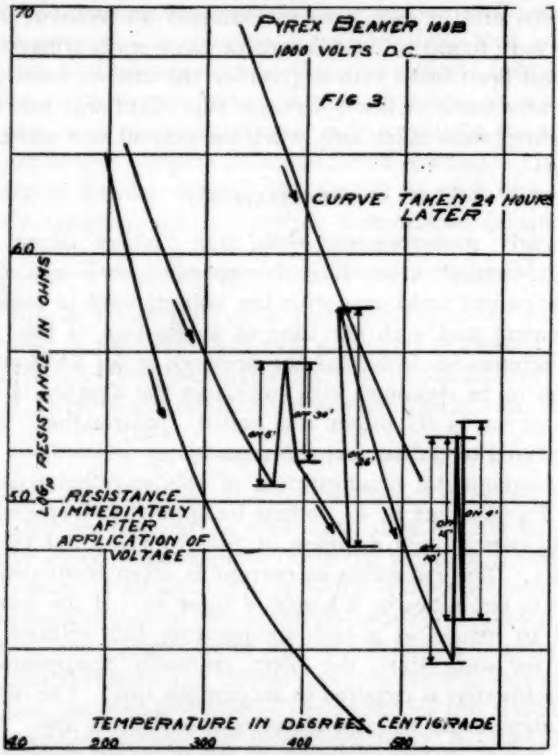

Fig. 3. Variation in resistance of glass cup resulting from polarization.

several successive tests. The fact that an appreciable time is required to obtain a reading, even with quick acting direct current indicating instruments, and that during this time the specimen is being polarized, is probably a complete explanation of the variation of apparent resistance with applied voltage. If the

applied D. C. voltage is suddenly reversed after a specimen has become polarized to a considerable extent, the initial current in the new direction is found to be approximately equal in magnitude to the original current and much greater than the value immediately preceding the reversal. This implies a counter E. M. F. and an attempt was made to observe such an effect by connecting an electrostatic voltmeter across the specimen. No residual deflection of this meter was observed when the supply current was removed, even after long continued polarization of the specimen. This result is to some extent in contradiction to facts mentioned by other observers.[3]

A magneto having alternate distributor points of the same polarity connected together was also used as a source of voltage and the polarizing effects found to be in every way similar to those obtained with a steady D. C. source of the same average voltage (150 volts).

When alternating current is applied to a fresh specimen, there is no polarizing effect and the current remains constant indefinitely, except when the current is so large as to produce heating of the specimen. When alternating current is applied to a specimen which has been previously polarized by direct current, the polarization disappears at a more rapid rate than if the alternating current had not been applied.

An attempt to throw light on these complex phenomena was made by applying alternating and direct current simultaneously to a specimen. This was accomplished by connecting a transformer in series with a generator. By opening the primary circuit of the transformer, or the field of the generator, either source of E. M. F. could be eliminated without opening the circuit or interfering with the current flow from the other source. The A. C. voltage was measured across the transformer terminals with a moving iron voltmeter, and the D. C. voltage by a d'Arsonval type D. C. voltmeter across the generator. The alternating current through the specimen was passed through the moving coil of an electro-dynamometer, the fixed coil of which was excited by an alternating current of constant magnitude and in

[3] MAXWELL, J. C. Electricity and Magnetism. Ed. 3. 1: 393.

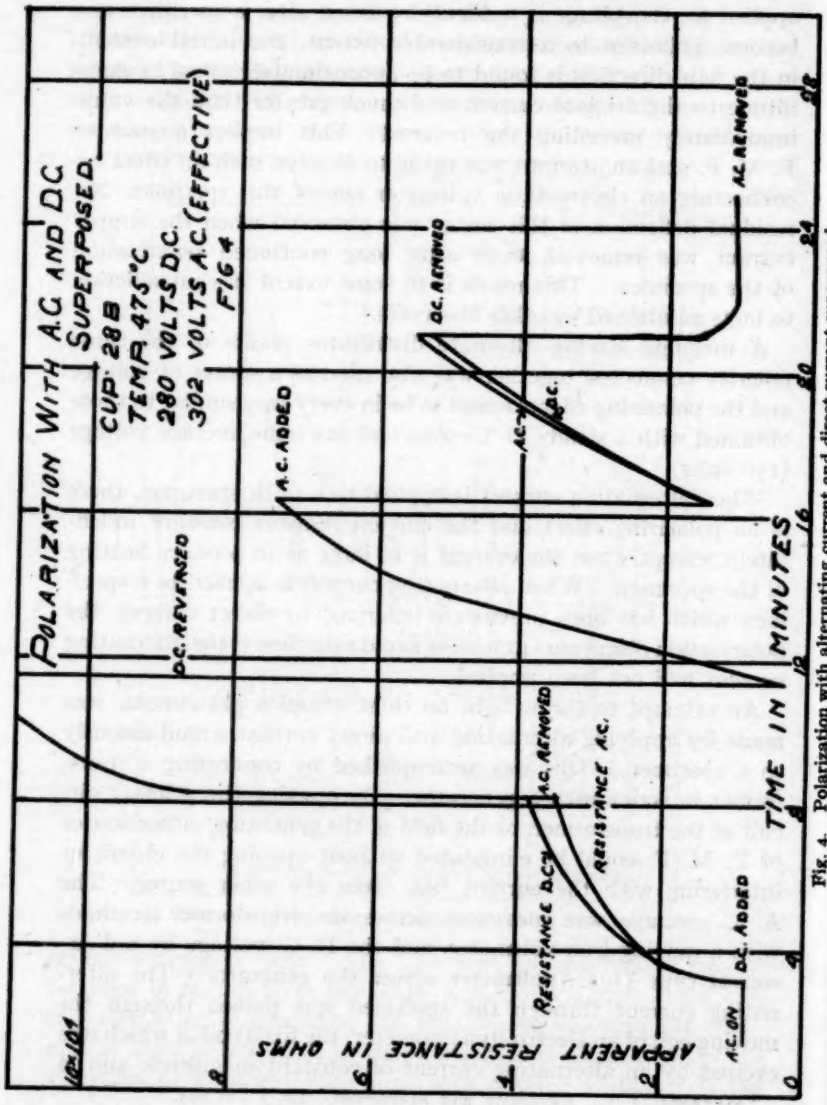

Fig. 4. Polarization with alternating current and direct current superposed.

the same phase as the alternating voltage applied to the specimen. The direct current through the specimen was measured by a D. C. milliammeter connected in series with the specimen and the dynamometer. With this arrangement, each pair of instruments measured only its particular component of the resultant current and voltage and was not affected by the presence of the other component. Figure 4 shows the variation with time during the course of the experiments of the resistances as computed from the two components of the current. In this experiment the maximum value of the A. C. voltage was greater than the D. C. voltage, so that the resultant voltage applied to the specimen reversed in sign during each alternation. Other experiments, in which the maximum alternating voltage was less than the D. C. voltage, and the resultant voltage was consequently unidirectional, showed substantially the same effects. Throughout the experiments, the temperature was held as nearly constant as possible, but a gradual drift of resistance will be noticed, which can be accounted for by a slight change of temperature. It appears from these results that the resistance of the specimen is substantially the same for both the alternating and direct currents for all states of polarization. Or, in other words, the polarization produced by the direct current offers resistance to the passage of the alternating current and the depolarization produced by the alternating current reduces the resistance offered to the passage of the direct current.

When alternating current alone was applied to a fresh specimen, the power factor of the circuit was found to be substantially unity. If, however, the specimen had recently been polarized by the application of direct current, the power factor was somewhat reduced; values as low as .9 having been observed.

The data described above are quite insufficient for the development of any complete theory of this "polarization," but it would appear that the assumption of a counter E. M. F. is ruled out by both the experiments of combined alternating and direct current and by the difficulty of imagining a mechanism capable of producing a counter E. M. F. of the order of several thousand volts, which would be required to produce the observed decrease

of current. A possible explanation may be developed on a basis of the migration away from one electrode, of the ions carrying the current, thus leaving a scarcity of carriers for the further passage of current in the original direction, but providing a plentiful supply for currents in the reversed direction. Another suggested explanation is the formation of resisting films which may cover a considerable part of the area of the electrodes but which are readily removed by electrolysis on reversal of the current. Tests made using platinized surfaces as electrodes instead of the melted solder showed no difference of behavior. It may be noted in this connection that when the samples were removed after cooling, the solidified solder adhered firmly to both surfaces of the cups which had been tested with direct current, but could be very readily peeled off from specimens which had been tested on alternating current.

DISCUSSION OF METHODS FOR MEASURING RESISTANCES

As a result of the data obtained in the preliminary experiments just described, it was decided to adopt as the most satisfactory method for the rapid comparison of different types of insulating materials, the volt-ammeter method using alternating current. Under these conditions the observed resistance is substantially independent of the frequency, voltage and time of application, and the convenient values of 60 cycles and 500 volts were adopted for the later work. Figure 2 shows the typical results obtained by this method and indicates the agreement attainable on successive runs even at different voltages. It should be remembered, however, that the results thus obtained are for the material in the unpolarized state and, when in actual use in ignition systems, the material may show a much higher resistance to the unidirectional impulse from the magneto.

Of other possible methods for such work, a bridge method using D. C. would be objectionable because of the variable amount of polarization which would occur. Attempts were made to use alternating current as a source but the measurements are complicated by the effect of stray capacities shunting the high resistances which are necessary, and the time required to

obtain a balance on the bridge is a serious draw-back because of the rapid change in the resistance to be measured with even slight drifts of temperature.

The megger, while extremely rapid and convenient, is open to the disadvantages of polarization and to the fact that the voltage supplied varies very considerably with the resistance of the specimen under test.

The use of a magneto in place of alternating current as a source has the great advantage that it approximately duplicates the conditions of operation in the engine. The magneto, however, is very variable in its output, both from instant to instant and as a result of permanent changes in the magnets, contact points, etc. Moreover, there is an abrupt change in the operation of the machine when the resistance of the specimen becomes so low as to cause the spark in the safety gap to cease, and also the total variation of the current delivered with various resistances in the circuit is comparatively slight, with this type of machine.

A method involving the measurement of the rate of loss of charge from a condenser connected in parallel with the specimen has been used by Cunningham. This method imitates the conditions of operation much more closely than does the A. C. method but not as perfectly as the use of a magneto as a source. The principal objections are the very delicate string electrometer which is required and the necessity of recording the result photographically.

TYPICAL RESULTS AND CONCLUSION

The following table gives the results obtained by the use of the alternating current method on a number of types of samples, the significance of the various constants being the same as those defined on page 257.

These figures show a wide variation in the resistance of the different materials but a rather surprising similarity in the constant b which is a measure of the temperature coefficient of their resistance. It should be mentioned in this connection that while successive measurements with alternating current on a single specimen give results repeating to a few percent, yet measure-

TABLE I

RESISTIVITY OF INSULATING MATERIALS

Material	c	b	T_ρ	ρ at 500° C.
Fused silica	11.8	.0065	890° C.	340×10^6
Best porcelain tested	11.2	.0066	790	80×10^6
Typical mica plug	12.1	.0085	720	70×10^6
Average three aviation porcelains	11.5	.0085	650	40×10^6
Average automobile porcelain	10.2	.0085	490	0.8×10^6

ments on different specimens of material which are supposed to be identical show wide variations in resistivity amounting in some cases to a factor of 10. This fact tends to indicate that the conduction is due to a considerable extent to the presence of small amounts of impurities which may vary greatly in amount without appreciably affecting the composition of the material as a whole.

It appears from the above data that the A. C. method developed is very practical and convenient for comparative measurements on samples of this character, but that there is a very wide field of investigation concerning the phenomenon of polarization and much interesting work may be done in developing theories as to the precise mechanism by which conduction is carried on in this class of materials.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The Board of Managers met on April 14. Routine business was transacted and new members elected. Mr. H. V. HARLAN was appointed an associate editor to succeed Mr. J. B. NORTON, who had resigned on account of absence from Washington.

The following persons have become members of the ACADEMY since the last issue of the JOURNAL:

Professor CHARLES O. APPLEMAN, Maryland Agricultural Experiment Station, College Park, Maryland.

Miss ELEANORA F. BLISS, U. S. Geological Survey, Washington, D. C.

Mr. HARRY V. HARLAN, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Dr. S. L. JODIDI, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Mr. IRWIN G. PRIEST, Bureau of Standards, Washington, D. C.

ROBERT B. SOSMAN, *Corresponding Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 812th meeting was held at the Cosmos Club, January 18, 1919. President HUMPHREYS in the chair, 48 persons present. The minutes of the 809th and 811th meetings were read in abstract and approved.

The paper of the evening was presented by Major L. T. SUTHERLAND on *Some of the accomplishments of the research division of the chemical warfare service.*

There was no discussion of the paper as such. However, the speaker expressed his willingness to answer questions and his replies to the questions asked him brought out many interesting points.

Upon motion duly seconded a unanimous vote of thanks was tendered the speaker. Adjournment took place at 10:09 p.m., following which there was a social hour with light refreshments.

The 814th meeting was held at the Cosmos Club, February 15, 1919. President HUMPHREYS in the chair, 45 persons present. The minutes of the 813th meeting were read in abstract and approved.

The first paper was presented by Mr. L. A. BAUER on *The field of a uniformly magnetized elliptic homoeoid and applications.*

There have been repeated occasions in the course of the author's investigations when he had need for the simplest possible expressions defining the magnetic field of certain magnetized bodies, such as ellipsoids of revolution, homoeoids, focaloids and cylinders. A variety

of investigations will be found in treatises and papers by eminent authors, but the derived expressions either stop at the gravitation potential and intensity components, or but special cases of magnetization are treated. Furthermore the published expressions for general cases are often needlessly complex or they contain errors of one kind or another which in some instances have been repeated by later authors. Hence, the attempt was made to derive the desired expressions in the simplest manner possible for practical application. Certain war problems gave added zest to this attempt.

According to Poisson, who first solved the problem of induced magnetism in an ellipsoid placed in a uniform magnetic field, if V' be the gravitation potential at the point (x, y, z) of a body of uniform density ρ, then $-\frac{\partial V'}{\partial x}$ is the magnetic potential of the same body uniformly magnetized in the direction x with the intensity $A = \rho$. Similarly with regard to any other direction of uniform magnetization. If the uniform magnetization results from magnetic induction, the magnetizing field at all points in the interior of the body will be uniform. So that if the external magnetizing field is uniform, the magnetic field resulting from the magnetization will also be uniform for all points in the interior of the body.

The ellipsoid is the only body for which $\frac{\partial V}{\partial x}$ is a linear function of the coordinates x, y, z in the interior, and V, accordingly, a quadratic function of the coordinates. Poisson's method can, therefore, be applied to the case of the ellipsoid.

Hence if A, B and C be the intensities of magnetization parallel to the three axes of the ellipsoid, and X', Y' and Z' the components of gravitational intensity due to a homogeneous ellipsoid of uniform density $\rho = 1$, the magnetic potential due to the ellipsoid at any external point as resulting from the induced magnetization will be

$$V = AX' - BY' - CZ' \qquad (1)$$

As defined by Thomson and Tait[1] "an elliptic homoeoid is an infinitely thin shell bounded by two concentric similar ellipsoidal surfaces." The total intensity produced by such a shell at points within the hollow interior is zero, and at external points anywhere infinitely near the homoeoid it is perpendicular to the surface, directed inward and equal to $4\pi\rho t$, where ρ is the constant density of the homogeneous mass and t is the thickness of the shell at the point for which the intensity is sought.[2] Since, furthermore, any two confocal homoeoids of equal masses produce the same intensity at all points external to both, we have in general that the *total intensity produced by a homogeneous elliptic homoeoid at an external point* (x, y, z) *is equal to* $4\pi\rho t$, ρ *being the constant density and* t *the thickness of the elliptic homoeoid at the point* (x, y, z),

[1] THOMSON and TAIT's Natural Philosophy. Pt. 2: 43, footnote 2.

[2] Idem. Pt. 2: paragraphs 519–525.

confocal to the given homoeoid and passing through x, y, z; the intensity is along the normal and directed inward, or towards the given shell.

On the basis of equation (1) and MacLaurin's theorem the author has deduced:

1. Expressions for the field of an inductively magnetized rotation ellipsoid in a more convenient form for the general case than previous ones.

2. Expressions for the field of an inductively magnetized prolate elliptic homoeoid have been established, possibly for the first time.

It was also shown that expressions in finite form may be established for the field of an inductively magnetized elliptic homoeoid in general—that it is not necessary to assume a rotation elliptic homoeoid. This matter is of special interest in view of the fact that expressions for the field of an inductively magnetized solid ellipsoid, in general, have not yet been established in finite form.

In conclusion various applications of the derived formulae were given.

The paper was illustrated by lantern slides and was discussed by Messrs. ABBOT, LITTLEHALES, SOSMAN and HUMPHREYS.

The second paper, also illustrated by lantern slides, was presented by Mr. S. J. MAUCHLY on *Some results of atmospheric-electric observations made during the solar eclipse of June 8, 1918.*

The observations forming the subject of this paper were made in the belt of totality near Lakin, Kansas, in accordance with the general plan of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington for magnetic and electrical observations during the total solar eclipse of June 8, 1918. The observing station was located on a level treeless plain and the general weather conditions on the afternoon of the eclipse were favorable for atmospheric-electric observations. The period of totality at Lakin was of about 84 seconds duration.

The potential-gradient was determined from eye readings of an electroscope giving the p. d. between the earth and an ionium collector supported at a distance of 95 cm. above the ground, from the middle of a long, insulated, horizontal wire. Observations were made every two minutes over a period of 6 hours approximately symmetrical about the time of totality. The main results may be summarized as follows:

(1) Beginning 8 minutes before and continuing throughout totality there was a rapid but nearly uniform decrease of the potential-gradient amounting to about 25 per cent of the values immediately preceding. The general minimum thus established persisted for about 20 minutes after totality and was marked by a sharp secondary minimum 6 minutes after mid-totality.

(2) Throughout the general minimum referred to there was *almost total absence* of the irregular, short-period, fluctuations which characterized the potential-gradient on the afternoon of the eclipse. Beginning 20 minutes after totality and continuing for about 20 minutes there was a marked but gradual increase to approximately normal

values of both the gradient and the amplitude of its short-period fluctuations.

For the observations of the specific conductivity of the air the aspiration apparatus devised by Gerdien was employed. By the use of a separate apparatus for each, it was possible to make approximately simultaneous observations of the positive and negative conductivities. The time for a single determination was 2 minutes, and, except for the time required for making frequent calibration and leak tests, the observations were made continuously throughout a period of 6 hours symmetrical about totality. The results showed, for both signs, a very marked increase in conductivity just before totality. These abnormal values continued for about 20 minutes after totality when both conductivities began to decrease. The time of return to normal afternoon values, for both signs and also for the total conductivity, corresponded very closely to the time when the potential-gradient regained its normal values.

A short résumé of the results of atmospheric-electric observations during previous eclipses by other observers was also given and comparisons made with the foregoing.

Adjournment took place at 10:20 p.m. and was followed by a social hour and refreshments.

The 816th meeting, a joint meeting with the Washington Academy of Sciences, was held at the Cosmos Club, March 15, 1919, President Humphreys presiding.

The address of the evening was given by Dr. H. D. CURTIS on *Modern theories of spiral nebulae*.

This address was illustrated by lantern slides and has appeared in this JOURNAL (9: 217. 1919).

S. J. MAUCHLY, *Recording Secretary*.

SCIENTIFIC NOTES AND NEWS

Dr. PAUL BARTSCH, of the National Museum, has returned from an extended lecture tour to various army camps.

Mr. C. F. BOWEN resigned from the Geological Survey in April to enter the employ of the Carter Oil Company. He will leave soon for a six months' trip in Venezuela and Colombia.

Mr. F. W. DEARBORN of the Ordnance Department has joined the staff of the Bureau of Standards and will be engaged in research on the chemistry of cellulose.

Mr. WILSON B. EMERY resigned from the Geological Survey in April to enter the employ of the Ohio Oil Company at Cheyenne, Wyoming.

The Chicago Speedway Hospital has been turned over to the Public Health Service, and two of the seven subdivisions of the building will be devoted to research and to the instruction of public health officers. This part of the work of the hospital will be under the direction of Dr. JOSEPH GOLDBERGER, of the Hygienic Laboratory.

Dr. J. A. HARKER, formerly of the National Physical Laboratory, in London, visited Washington in March on business connected with the organization of scientific and industrial research in England.

Mrs. PHOEBE APPERSON HEARST, a patron of the ACADEMY, died at her home at Pleasanton, California, on April 13, 1919, in her seventy-seventh year. She was the widow of the late Senator George Hearst, of California, coming with him to Washington in 1886. She took an active part in educational affairs during her residence in the city. She was elected a patron of the ACADEMY in 1901.

Mr. O. B. HOPKINS, of the Geological Survey, is on leave of absence and is engaged in work for the Imperial Oil Company in Canada.

Mr. H. E. HOWE, formerly manager of the commercial department of A. D. Little, Inc., of Cambridge, Massachusetts, will hereafter devote his efforts to the interests of the National Research Council and particularly to the work of its Division of Industrial Research. Mr. Howe was attached to the Nitrate Division of the Ordnance Department, U. S. A., during the latter part of the war.

Mr. M. B. LONG, of the gas laboratory of the Bureau of Standards, has resigned in order to accept a position in the research laboratory of the Western Electric Company, in New York City.

Mr. J. B. NORTON, of the Bureau of Plant Industry, who has been appointed Agricultural Explorer in the Office of Foreign Seed and Plant Introduction, has left Washington on an expedition to China.

Mr. B. E. SIVE, formerly of the chemical reagent testing laboratory

of the Bureau of Standards, is now with the American Colortype Company of Chicago, Illinois.

The Treasury Department published in April a "Manual for the Oil and Gas Industry under the Revenue Act of 1918," designed to assist the oil and gas producer to calculate the depletion of his reserves. Attention is called to the publication here as it is not issued by one of the scientific or technologic bureaus and might not reach the scientific public through the usual channels.

The Division of Biology and Agriculture of the National Research Council met in Washington, April 14. Fourteen members were nominated by 10 national societies of biology and agriculture, 3 each from the Botanical Society of America and the Society of American Zoologists, and one each from the other societies. These members nominated 8 members at large. The Washington members are: G. N. COLLINS, American Genetic Association; A. S. HITCHCOCK, Botanical Society of America; GEORGE R. LYMAN, American Phytopathological Society; CHARLES V. PIPER, American Society of Agronomy; A. G. MAYER, Carnegie Institution; C. F. MARBUT, Bureau of Soils; H. F. MOORE, Bureau of Fisheries, members-at-large.

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